

Development of Bi-Modal Nuclear Thermal Propulsion and Power Fuels

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Abstract: The development of high temperature nuclear fuel for use advanced space flight concepts such as Nuclear Thermal Propulsion (NTP) systems began with the Rover Program in 1955 and continued through programs such as NERVA, GE-710 and Argonne National Laboratory Nuclear Rocket. The basic nuclear rocket engine concept comprises a nuclear reactor used to heat a low molecular weight gas to as high a temperature, typically ~2700K, and force the expanding gas through a nozzle to generate thrust. Work is currently on going to re-establish the fabrication of NTP fuels. The technical problems of developing fuels and materials to meet the demanding operating requirements are very challenging. The principle is is one of demonstrated survivability under the temperature and environmental conditions for the required lifetimes normally measured in hours.

The next desired step to be undertaken is the development of a fuel that can operate under both NTP conditions, but can also be for longer periods of time (years) at lower temperatures to provide electrical power for the spacecraft during its flight time to Mars or other planets. The technical problems for developing fuels and materials to meet the demanding operating conditions of both propulsion at high ISP and power production for extended lifetimes are very challenging. The principle issues are demonstrated survivability under the temperature and operating conditions and dealing with the accumulation of fission products in the fuel material.

As a general conclusion, NTP fuel development is dominated by fuels and coating development to withstand the high temperatures and hydrogen erosion. Nuclear power production fuels development is dominated by maintaining fuel structure and minimization from effects of fission products on the reactor control and interaction with cladding and materials.

It appears that both demands can be met but will require some system trades in level of performance of the reactor as well as the nuclear system as well as significant development, testing and evaluation. Advanced technology concepts are needed to transfer heat from the reactor core during power production odes, but can withstand the high temperatures seen during propulsion cycles.